The DOE Water Cycle Pilot Study: Modeling and Analysis of Seasonal and Event Variability at the Walnut River Watershed

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RESEARCH OBJECTIVES

The DOE Water Cycle Pilot Study represents a successful multi-laboratory investigation to better understand water cycle variability—by evaluating DOE climate models, developing water isotopic data to constrain such climate models, and to test process descriptions and their sensitivity at multiple scales. The research objectives are to: (1) evaluate predictions of components of the water budget, using a set of nested models with different spatial resolutions, along with archived and new field data from the Walnut River Watershed (WRW); (2) evaluate multiscale water isotope modeling as a means of tracing sources and sinks within and external to the WRW and the Atmospheric and Radiation Measurements Program-Southern Great Plains (ARM SGP) site; (3) identify water-budget-model improvements and data needs over a range of scales. The DOE Water Cycle Pilot was funded for two years by DOE's Office of Basic Energy Research (BER), and resulted in several follow-on studies, including a paper by Sharif et al. (2005) on a 51-year simulation and derivation of scaling relationships for the Red-Arkansas River Basin.

APPROACH

Water isotopic measurements of precipitation, surface water, soils, plants, and atmospheric water vapor were collected every three months and during the DOE Intensive Observing Period, April 1 to June 30, 2002. Land-surface modeling compared 1 km fluxes for different modes and for a 51-year simulation. Different wetting and drying conditions caused by different controls were investigated. Multi-scale atmospheric simulations using the MM5 and radar-based data have been analyzed and are discussed below (Miller et al., 2005).

ACCOMPLISHMENTS

It was shown that isotopic sampling of rivers and lakes provides a good long-term average of precipitation patterns and helps to validate water cycle simulations in regional climate models, such as MM5. Analysis of the simulated MM5 6-hour precipitation and radar-derived precipitation has indicated that MM5 slightly underestimates at a 4 km resolution and lags behind the radar-precipitation onset. MM5 exhibits strong capabilities in predicting precipitation occurrences, with somewhat less accuracy in predicting precipitation amounts.

The TOPLATS land surface model was evaluated for a number of scenarios, resolutions, and periods. Eleven simulations were performed with different modes, with several variations in the representations of spatial variability of precipitation, land use, topography, and soils—to assess the sensitivity of the model response. Model results suggest that in parts of the catchment, evapotranspiration switched between being atmospherically controlled to soil-moisture controlled.

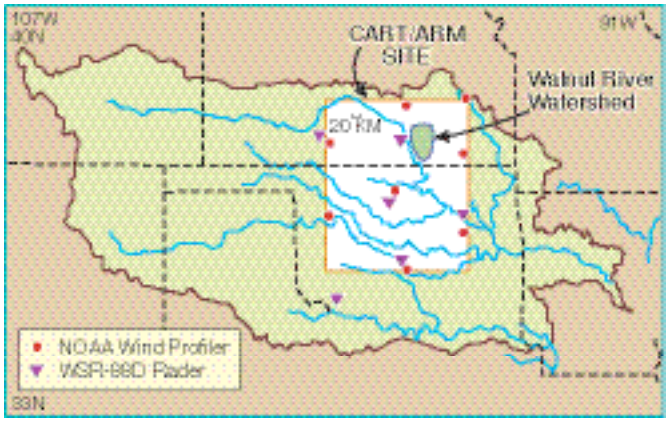

Figure 1. The ARM/CART Southern Great Plains Site within the Red-Arkansas River Basin

SIGNIFICANCE OF FINDINGS

The DOE WaterCycle Pilot Study resulted in a number of findings that are highlighted in Miller et al. (2005b). One key finding is the MM5 analysis indicating that simulations at 12 km resolution are more accurate than at 4 km, because of the scale-dependent parameterizations. Another key finding is the TOPLATS simulations indicating that a low parameter semi-distributed simulation replicates a high-parameter, fully distributed simulation with fair to good accuracy.

RELATED PUBLICATIONS

Miller, N.L., A.W. King, M.A. Miller, E.P. Springer, M.L. Wesely et al., The DOE Water Cycle Pilot Study. Bull. Amer. Meteoro. Soc., 86, 3, 359–374, 2005a. Berkeley Lab Report LBNL-53826.

Sharif, H. O., W. T. Crow, N. L. Miller, and E. F. Wood, Multi-decadal high-resolution land surface modeling study in the Southern Great Plains. J. of Hydrometeorology (submitted), 2005.

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